Ball has made all these the text for a clear account of our present knowledge of higher space. The two last chapters rapidly survey "Time and its Measurement" and "The Constitution of Matter."

Our analysis shows how great an extent of ground is covered by the "Mathematical Recreations," and when we add that the account is fully pervaded by the attractive charm Mr. Ball knows so well how to infuse into what many persons would look upon as a dry subject, we have said all we can to commend it to our readers. The book is most carefully printed (only three or four typographical errors have met our eye, and the figures on pp. 32 and 33 the student will recognize must be drawn incorrectly).

SOILS AND MANURES.

Soils and Manures. By John M. H. Munro, D.Sc. (Lond.) (London: Cassell, 1892.)

THE preface to this book informs us that "it is written for the use of young people in schools and colleges, and those numerous other readers who take an intelligent interest in the how and why of familiar facts and operations, yet have no special training in the language and methods of science."

We must admit that Dr. Munro has succeeded in his endeavour to write a book so simple that it may be put into the hands of a beginner with confidence that he will find few difficulties unexplained, and so trustworthy that the more advanced student may find it helpful and suggestive.

We are having a flood of small agricultural books just now, consequent upon the great movement for technical education in England, but we believe that this book will reach two classes of readers which the majority of other text-books do not seem to have affected. These two classes of readers are farmers and teachers in elementary schools. Too many of these books are written with the idea of preparing students for examination, and they may serve their purpose, but are not very likely to help forward the cause of technical education in agriculture to any considerable extent.

Such education has lately been much talked about, and written about also, and men of authority and experience have even gone so far as to say that the recent attempts to promote it have mostly been failures. But if the means employed have proved inadequate or unsuitable, it does not follow that technical education in agriculture is unnecessary, or that suitable means and methods of promoting it cannot be found.

To attempt to teach the principles of agriculture to men who have no knowledge of either elementary chemistry or botany can scarcely be expected to be generally successful, nor do we hear good accounts of lectures given to farmers by men whose agricultural experience has been mainly limited to the class-room and the laboratory, and who are apt to confound agricultural chemistry with agriculture itself. Yet there are very many earnest workers on the County Councils, who have the cause of agricultural education too much at heart to let a few failures and disappointments dishearten them, and, before very long, we feel sure that they will have more reason for congratulation than at present.

Meanwhile, we can welcome this book of Dr. Munro's and wish it the success it deserves, for not only does the author avoid errors himself but he corrects a few which some other writers of elementary text-books on agriculture have fallen into. Thus, on pp. 20 and 132, he removes the impression which many beginners get (from some "cram-books" we have seen) that silica in a soluble form is very essential as a plant-food, especially to cereals. Only those who are familiar with answers to examination papers in agriculture have any idea how frequently this mistake is made.

The first part of the book, comprising five chapters, will give the reader a very good account of soils, their formation and properties; also of plant-food in the soil, how it is increased, and how rendered available for the use of plants. Included in this first part are two chapters on "Improving the Land" and "Tillage Operations," from the pen of Prof. Wrightson. These fit in well with the rest of the work.

The second part deals with the subject of manures pretty exhaustively, the author giving many illustrations from the Rothamsted experiments. The last chapter, on "Special Manures," gives instructions for valuing artificial manures from the chemical analysis, and we feel sure that the matter dealt with in this chapter will be specially useful, and do at least a little to help the farmer from being defrauded by some few unscrupulous manufacturers, still, unhappily, existent amongst us.

OUR BOOK SHELF.

Catalogue of the Specimens illustrating the Osteology of Vertebrated Animals, Recent and Extinct, contained in the Museum of the Royal College of Surgeons of England. Part III., Class Aves. By R. Bowdler Sharpe, LL.D. (London: Printed for the College and sold by Taylor and Francis, Red Lion Court, Fleet Street, 1891.)

THE first point of interest in looking into this Catalogue was to ascertain which of the innumerable schemes of bird classification had been adopted by the author; we have so many of them nowadays. Sometimes they come upon us two at a time; and to make confusion worse, aged schemes of classification, which one hoped had long ago sunk into a dishonoured grave, are sprung upon us in a fresh edition. The plan followed by Dr. Sharpe is that of Mr. Seebohm, "elaborated in his 'Birds of the Japanese Empire,'" with a few modifications. Under each order is the diagnosis; and there are a few references to the anatomical literature of the subject, which is an addition to the value of the work. These are not very full, but perhaps it is hardly necessary that they should be. A feature of this catalogue is the introduction of illustrations; there are a good many of these—48 in all. They are for the most part figures of the skull, but the syringes of a few birds and the deep plantar tendons of more are also illustrated; two figures illustrate pterylosis, and two more the under surface of the foot. The illustrations in every case are good. The Catalogue is not encumbered with huge lists of synonyms: there is only the most recently accepted name given, together with a few of the most important synonyms. The collection of bones consists of 2380 specimens, representing altogether a little over one thousand species. Some of the fossil forms are of course represented by casts only; but a number of important extinct species, notably among the Dinornithidæ, are well represented by the actual remains, in many instances the types of the species in question. We may

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point out to the charitably disposed that there are a number of desiderata: there are, for example, no specimens of either the African or the American "Fin-foots."

LETTERS TO THE EDITOR.

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The Line Spectra of the Elements.

THE proper replies to Prof. Runge's letter in last week's issue of NATURE are three in number: viz. (1) that, as I pointed out in my former letter (NATURE of May 12, p. 29), the reasoning in my paper is valid if, as I there proved and as Prof. Runge now admits in the first sentence of his letter, Fourier's theorem can be applied to motions which approximate to non-periodic motions in any assigned degree and for any assigned time; (2) that I am not aware of anything I have written which countenances Prof. Runge's supposition that "Prof. Stoney has not noticed that a distinct property of the function is wanted in order to get a proper" [rather, a mathematically accurate] "resolution into a sum of circular functions"; and (3) that Prof. Runge is mistaken when he supposes that "the amplitudes and periods" [or frequencies] "of the single terms . . . do not approach definite values when the interval" [*i.e.* the periodic time of the recurrence required by Fourier's theorem] "increases indefinitely."

What the true state of the case is, is most easily shown as regards the frequencies of the lines; and as the proof is, I believe, new, and leads to a result of importance in the interpretation of spectra, I subjoin it.

Take a motion of the electron—

$$x = \text{The sum of partials such as}\left(a \sin \frac{2\pi kt}{j} + b \cos \frac{2\pi kt}{j}\right); \quad (1)$$

with similar expressions for the other two co-ordinates; in which the oscillation-frequencies, the k's, may be commensurable with one another, or incommensurable. If incommensurable, the motion is non-recurrent. Let this motion be arrested at intervals of T, and immediately started afresh as at the beginning. We thus obtain a recurrent motion consisting of a certain section of the motion (1) repeated over and over again. This new motion can be analyzed by Fourier's theorem, and we have to inquire what we thus obtain. Without losing anything in generality, we may confine our attention to the motion parallel to the axis of x, and to the single partial of that motion which is written out above, as all the partials lead to similar results.

Let us then examine by Fourier's method the motion which is represented by the equation—

$$x_k = a \sin \frac{2\pi kt}{j} + b \cos \frac{2\pi kt}{j} \quad . \quad . \quad . \quad . \quad . \quad (2, a)$$

from $t = 0$ till $t = \text{T}$, and which is repeated from that on at intervals of T. If T is a multiple of j/k, Fourier's theorem simply furnishes equation (2, a) as the complete expression for all time of the motion; so that in this case it indicates the same definite line in the spectrum as is furnished by the original partial of equation (1).

If T is not a multiple of j/k,

$$\text{T will} = (m + \alpha)\frac{j}{k},$$

where m is a whole number and α a proper fraction. Equation (2, a) then becomes

$$x_k = a \sin \frac{2\pi(m + \alpha)t}{\text{T}} + b \cos \frac{2\pi(m + \alpha)t}{\text{T}} \quad . \quad . \quad (2, b)$$

which is true from $t = 0$ till $t = \text{T}$, after which the motion is to be repeated. Then, by Fourier's theorem—

$$\left.\begin{aligned} x_k = \text{A}_0 + \text{A}_1 \sin \frac{2\pi t}{\text{T}} + \text{A}_2 \sin \frac{4\pi t}{\text{T}} + \quad . \quad . \quad . \\ + \text{B}_1 \sin \frac{2\pi t}{\text{T}} + \text{B}_2 \sin \frac{4\pi t}{\text{T}} + \quad . \quad . \quad . \end{aligned}\right\} (3)$$

is true of this motion for all time, in which

$$\text{A}_n . \int_0^{\text{T}} \sin^2 \frac{2\pi nt}{\text{T}} . dt = a \int_0^{\text{T}} \sin \frac{2\pi(m + \alpha)t}{\text{T}} . \sin \frac{2\pi nt}{\text{T}} . dt$$

$$+ b \int_0^{\text{T}} \cos \frac{2\pi(m + \alpha)t}{\text{T}} . \sin \frac{2\pi nt}{\text{T}} . dt;$$

$$\text{B}_n . \int_0^{\text{T}} \cos^2 \frac{2\pi nt}{\text{T}} . dt = a \int_0^{\text{T}} \sin \frac{2\pi(m + \alpha)t}{\text{T}} . \cos \frac{2\pi nt}{\text{T}} . dt$$

$$+ b \int_0^{\text{T}} \cos \frac{2\pi(m + \alpha)t}{\text{T}} . \cos \frac{2\pi nt}{\text{T}} . dt;$$

which, when integrated, give the following values for A_n and B_n—

$$\left.\begin{aligned} \text{A}_n &= \frac{a \sin 2\pi\alpha - b(1 - \cos 2\pi\alpha)}{2\pi}\left(\frac{1}{d} - \frac{1}{s}\right) \\ \text{B}_n &= \frac{a(1 - \cos 2\pi\alpha) + b \sin 2\pi\alpha}{2\pi}\left(\frac{1}{d} + \frac{1}{s}\right) \end{aligned}\right\} \quad . \quad . \quad . \quad (4)$$

where d stands for $(m - n + \alpha)$, and s for $(m + n + \alpha)$.

This furnishes a very remarkable spectrum, a spectrum of lines that are equidistant on a map of oscillation-frequencies, and that extend over the whole spectrum. But they are of very unequal intensities. If T is a long period, m is a high number. The lines are then ruled close to one another, and their intensities are insensible except when n is nearly equal to m, the two brightest lines being the next to the position of the original line of equation (1), one on either side of it, and the others falling off rapidly in brightness in both directions.

If we take a longer period for T, m becomes a still higher number; the lines are more closely ruled and are more suddenly bright up to those on either side of the position of the original line of equation (1), to which also they are now closer; so that, at the limit, when T increases indefinitely, equation (3) becomes a mathematical representation of the original line of equation (1).

This interesting investigation is all the more important as it gives a clue to how rulings of lines which are equidistant and brighter up to the middle may arise; and I feel sure that Prof. Runge will join me in not regretting that he expressed the doubts which led to its solution.

G. JOHNSTONE STONEY.

9 Palmerston Park, Dublin, June 3.

Stone Circles, the Sun, and the Stars.

ARTICLES by Mr. Norman Lockyer and Mr. Penrose, recently published in NATURE, have dealt with the positions of ancient Egyptian and Greek temples with relation to the rising sun, and to the pole star, or some star or stars in its vicinity. For some years past I have endeavoured to show, in papers read before the British Association and other Societies, that our stone circles had a relation to the rising sun, indicated usually by an outlying stone or by a notable hill-top in the direction in which the sunrise would be seen from the circle, and I have in some cases found similar indications towards the north, which may have referred to the pole or other northern star or stars. A paper containing many details as to these cases will shortly appear in the Journal of the Royal Archæological Institute.

There are six circles on Bodmin Moors, which at first sight appear to have no relation to each other, but which, if the 6-inch Ordnance map is to be relied upon, would seem to have been arranged on a definite plan (see accompanying plan).

The Stannon and Fernacre Circles are in line 1° (true) north of east with the highest point of Brown Willy, the highest hill in Cornwall; and the Stripple Stones and Fernacre Circles are in line with the summits of Garrow and Rough Tor, at right angles with the other line—namely, 1° west of (true) north. A line from the Trippet Stones Circle to the summit of Rough Tor would also pass through the centre of one of the Leaze Circles (about 12° east from true north). Other hills are in the direction of the rising sun. The Trippet Stones are 11½° south of west from the Stripple Stones, 10° east of south from the Stannon Circle, and about 13° west of south from the Fernacre Circle. The respective bearings of the other circles have already been given, and all are true (not magnetic) according to the 6-inch Ordnance map.

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